EXPERIMENTAL RESEARCH ON MECHANICAL PROPERTIES OF LAMINATED POPLAR WOOD VENEER/PLASTIC SHEET COMPOSITES

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Abstract. In this study, to improve the structural applications of wood plastic composite (WPC) according to its relatively lower MOE, wood veneer and plastic sheets were laminated to form laminated WPC (LWPC). Bonding performance tests were conducted to determine the effects of coupling agent and processing on bonding performance between wood and plastic, followed by mechanical properties tests. The bondlines between wood and plastic were examined using scanning electron microscopy (SEM). The results showed the following. 1) Delamination of untreated LWPCs was converted into wood fracture by adding a coupling agent. 2) The bending strength and tensile strength are both higher than those of the conventional WPCs, and the MOE of parallel multilayered LWPCs was significantly increased. The parallel multilayered LWPC with a density of 0.6 g/cm^3 and wood-to-plastic ratio of 3:1 had an MOE of 11,490 MPa, and the bending and tensile strength were 40.36 MPa and 31.47 MPa, respectively. 3) SEM indicated that a strong interfacial connection in LWPC was obtained. This study demonstrated that the configuration of LWPC in combination with laminated veneer lumber and conventional WPC technologies is an effective method to improve mechanical properties. The LWPC can be used as a load-bearing material in timber structure.

Keywords: Wood plastic composites, laminating configuration, interface, mechanical properties, bonding performance.

INTRODUCTION

Wood-plastic composite (WPC) was traditionally made of wood flour or tiny wood fibers and plastic matrix (Afrifah et al 2010; Stark et al 2010; Ayrilmisa et al 2015; Schirp and Shen 2016). WPC combined great properties and cost attributes of both wood and plastic and had excellent outdoor durability (Nourbakhsh and Ashori 2008). The plastic matrix provides protection to the natural fiber from influence of the moisture, fungus, and insects. Because of these facts, WPCs are widely used in outdoor applications (Ashori 2008; Afrifah et al 2010; Leu et al 2012). Wood-based composites were mostly assembled with the adhesion of formaldehyde-containing adhesive, so there was emission of unhealthy formaldehyde (Lee et al 2002). Plastic matrix played an important role for its bonding performance along with wood flour in WPCs. So when used in indoors, WPCs were defined as friendly wood-based materials because they can avoid formaldehyde release (Afrifah et al 2010; Stark et al 2010; Ayrilmisa et al 2015; Schirp and Shen 2016).

The plastics used as matrix in WPCs were polyethylene (PE), polypropylene (PP), and polyvinyl chloride with a melting point below 200°C because of the limitation of thermal degradation of wood materials (Winandy 2013). Wood polymers in WPCs contained large amounts of hydrophilic hydroxyl groups, and they were incompatible with hydrophobic thermoplastics (Li et al 2013). This incompatibility generally led to poor interfacial adhesion between wood and plastic, which resulted in the reduction of mechanical properties (Deka and Maji 2012; Hosseinaei et al 2012). Furthermore, the incompatibility may provide pathways for moisture uptake and biological attack (Pendleton et al 2002). Wood surface modification using coupling agents, such as silane and maleic anhydride (MAH), was useful (Arbelaiz et al 2005; Abdelmouleh et al 2007). Wood modification can effectively improve the interfacial bonding (Ayrilmis et al 2011; Hosseinaei et al 2012; Islam et al 2012; Segerholm et al 2012). MAH was widely used because it was able to build ester bonds between hydrophobic plastic and hydroxyl groups in wood surface (Arbelaiz et al 2005; Soccalingame et al 2015). The mechanical properties of WPCs increased with addition of MAH (Kord 2011).

The WPC exhibited available mechanical properties in nonstructural applications (Maiti and Singh 1986). The bending modulus of conventional WPC was not higher than 3300 MPa, and the bending and tensile strength were less than 46.3 MPa and 29.4 MPa, respectively (Li et al 2013; Wei et al 2013a; Arab and Islam 2015; Yang et al 2015). The MOE of wood fibers was approximately 40 times higher than that of PE and the strength about 20 times higher (Bengtsson et al 2005), and the mechanical properties of solid wood are four times higher (Stark and Rowlands 2007; Chaudemanche et al 2018), so it can be concluded that the mechanical properties of WPC were generally provided by wood (García et al 2009) and plastic played a role in the transfer of stress (Wei et al 2013a). WPCs have received considerable attention in recent decades, but their modulus was not high enough when used as structural building materials and may cause excessive deformation or led to be destroyed if used directly.

The lamination process with thinner layers can greatly disperse the natural defects of solid wood and reduce the variability (Kılıç 2011). Laminated veneer lumber is an engineered wood product suitable for the application in civil construction, which is made by laminating multilayers of veneers in the longitudinal direction (Wei et al 2013b; Melo and Menezzi 2014). It was reported that laminated veneer lumber can be used as a structural wood-based material according to its high strength and modulus (Melo and Menezzi 2014; Bal 2016). Poplar is a fast-growing wood species with high productivity and has been widely planted in China for several decades. Some characteristics benefit poplar processing such as fast drying and the possibility to be rotary peeled, chipped, and grinded to produce veneer, particle, and fiber without or with a slight pretreatment (Yue et al 2016, 2017). The study of WPCs in nonstructural application, such as process optimization, durability, and thermal resistance improvement is well-documented, but it is seldom used as a load-bearing construction material. Laminated veneer lumber has been successfully industrialized in structural application, and high strength was one of the most remarkable advantages of laminated veneer lumber, which was conventionally made of natural wood species. To our knowledge, there are no previous literature studies on structural laminated fast-growing wood species veneer and plastic composites. To improve the modulus of WPCs, the production method of laminated veneer lumber may be used for reference to produce structural WPCs, considering environmental concerns of formaldehyde-containing adhesive and mechanical properties (Hu et al 2005; Fang et al 2013a, 2013b), and the wood veneer and thermoplastic sheet were used rather than wood flour or small wood fiber.

The primary objective of this study was to provide a structural laminated WPC (LWPC) with fast-growing poplar wood for load-bearing materials in building structures in combination with conventional WPC and laminated veneer lumber technologies.

MATERIALS AND METHODS

Materials

Two-millimeter-thick poplar veneers from Siyang Chengyuan Wood Industry Co., Ltd. (Suqian, Eastern China) were dried to an MC around 12% with specific gravity of 0.444 g/cm^3. A 0.3-mm-thick thermoplastic sheet with a PP and PE weight ratio of 1/1 (density of 0.93 g/cm^3) was purchased from market in Nanjing, eastern China. MAH was purchased from Xilong Chemicals Co., Ltd. (Guangdong, Southern China).

Preparation of Laminated Wood-Plastic Composites

The poplar veneers were modified with the distilled MAH solution with a concentration of 4% or 8% (w/v) for 1 h under normal temperature and pressure condition and were air-dried at room temperature for 24 h. The pretreated veneers were then placed in an oven at 60°C for at least 1 h to achieve 3-5% MC. Wood veneers and thermoplastic sheets were assembled by flat-pressed technology using an XLB universal panel-processing machine (Qingdao, China). Three replicates were conducted in each group. The cross three-layered LWPC were produced at 140, 160, or 180°C, respectively. These temperatures were chosen according to the melting temperature of thermoplastic compound and the limitation of pyrolysis temperature of wood. The pressure was set 0.8 MPa, and the pressing period was set 6 min according to Wang et al (2003). Bonding performance, including bonding strength, wood failure percentage, failure mode, and delamination length was recorded. The hot-pressing temperature and MAH solution concentration can be optimized according to the previously mentioned test results, and then the parallel multilayered LWPCs with a thickness of 12 mm were fabricated (Fig 1). In the parallel multilayered LWPC sample preparation, three levels of product density (0.6, 0.8, and 1.0 g/cm^3) and three levels of wood-to-plastic ratio (3:1, 3:2, and 3:3 w/w) were applied. The three- and multilayered LWPC specimens were conditioned at a temperature of 20°C and an RH of 65% for more than 2 wk to achieve EMC before being tested.

Melting Temperature Measurement

The melting temperature of thermoplastic compound was determined with 200 F3 differential scanning calorimetry (NETZSCH Group, Selb, Germany). The scanning temperature was from 20 to 210°C under a nitrogen atmosphere, and the heating rate was 1 centigrade every 6 s.

Bonding Performance Tests

Fabrication of the cross three-layered LWPCs is shown in Fig 2(a). Bonding performance of the cross three-layered LWPC specimens was tested by longitudinal tensile shear strength method according to China Standard GB/T 17657 (2013). The test setup and the dimensions of test pieces are shown in Fig 3. Test pieces were immersed in boiling water for 4 h and then dried in a thermostatic drier for 18 h at a temperature of 60°C. After that, they were immersed in boiling water at room temperature for 1 h and immersed in water at room temperature for 1 h. The duplicates were 12 for each group. Then, the wood failure percentage was determined according to China Standard LY/T 2720 (2016), and failing modes

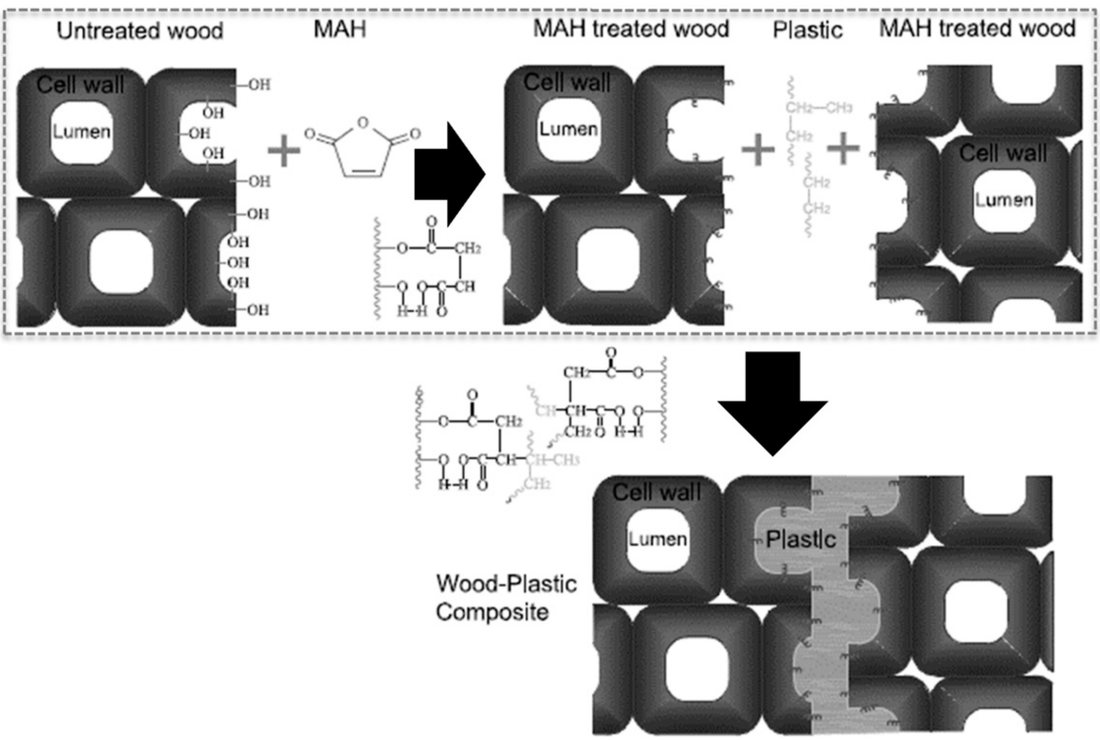


Figure 1. Schematic illustration of production for laminated wood plastic composite.

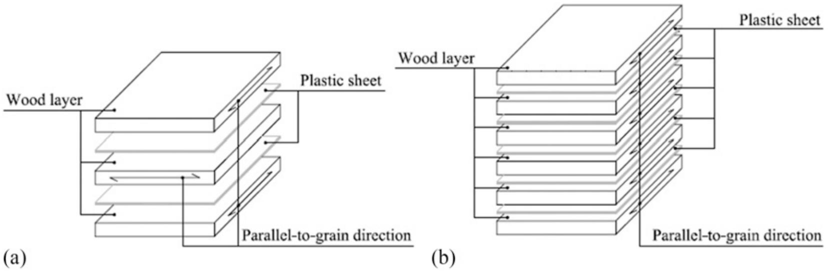


Figure 2. Fabrication of laminated wood plastic composites before hot-pressing: wood grain was perpendicular (a) and parallel to each other (b).

were recorded. The bonding strength was defined with the following formula:

$$X_c = \frac{P_{\max}}{(b \cdot l)}, \quad (1)$$

where X_c is the bonding strength of the cross three-layered LWPC (MPa), $P_{\max}$ is the ultimate bearing capacity (N), and b and l are the width and length of the tested surface, respectively (mm).

Fabrication of the parallel multilayered LWPCs is shown in Fig 2(b). Bonding performance of the parallel multilayered LWPC specimens was tested by boiling water immersion method according to China Standard GB/T 20241 (2006). Test pieces were immersed in boiling water for 4 h, and then immersed in water at room temperature for 1 h. After that, they were dried in a thermostatic drier for 24 h at a temperature of 70°C. Then, the length of delamination on four sides of test pieces was measured, and the ratio of delamination to the total length of glue lines on four sides was calculated. The ratio of delamination (D_e) was determined using the following formula:

$$D_e = \frac{l_t}{L_0 \cdot 100}, \quad (2)$$

where D_e is the ratio of delamination (%), l_t is the total length of delamination on four sides (mm), and L_0 is the total length of glue lines on four sides (mm).

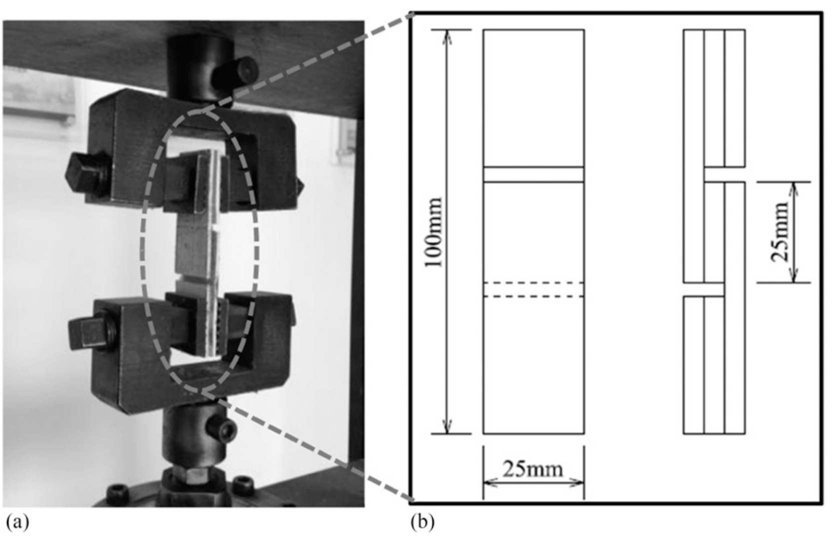


Figure 3. Test setup (a) and specimens' dimension of bonding strength in longitudinal tensile shear (b).

Mechanical Tests

Fabrication of LWPC in mechanical tests is shown in Fig 2(b). Tests for mechanical properties were performed in MTS electromechanical universal wood-testing machine (MTS Systems Co., Ltd., Shanghai, China) with an ultimate capacity of 50 kN and with a 50-N load cell. Loads were automatically measured and recorded by a universal testing machine. The specimens used for static flexural property and parallel-to-grain tensile strength testing were all cut to dimensions of 12 × 30 × 350 mm^3 (thickness by width by length). The speeds of bending and tensile load were applied continuously at a rate of 2 mm/min and 1 mm/min, respectively. For the parallel multilayered LWPC specimens, static bending strength (MOR), MOE, and parallel-to-grain tensile strength were measured according to China Standard GB/T 26899 (2011). The duplicates were both 12 for each group in bending and tensile tests. The MOE was experimentally determined by the slope of deflection and bending load that ramped from 100 N to 300 N. The MOR, MOE, and parallel-to-grain tensile strength (TS_l) were determined using the following formulas:

$$\mathrm{MOR} = 3 \cdot P_{\max} \cdot l / \left(2 \cdot b \cdot h^2\right), \tag{3}$$

$$\mathrm{MOE} = \Delta P \cdot l^3 / \left(4 \cdot b \cdot h^2 \cdot \Delta y\right), \tag{4}$$

$$\mathrm{TS}_l = P_{\max} / (b \cdot h), \tag{5}$$

where MOR is the bending strength (MPa); MOE is the modulus of elasticity (MPa); TS_l is the parallel-to-grain tensile strength (MPa); $P_{\max}$ is the ultimate bearing capacity (N); ΔP is an increment between upper and lower load limits (N); Δy is an increment of deflection corresponding to the ΔP (mm); and l, b, and h are the span, width, and thickness of tested specimens (mm), respectively.

RESULTS AND DISCUSSION

Bonding Performance

The DSC thermogram of heat reaction of thermoplastic compound is plotted in Fig 4. Two obvious exothermic peaks can be observed from Fig 4. The lower exothermic peak was 122.8°C at the melting temperature of PE. The higher one was 165.2°C at the melting temperature of PP. The PE or PP gradients in plastic compound can flow easily at the exothermic peak.

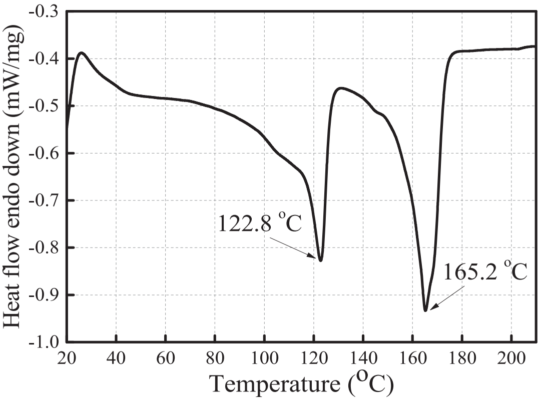


Figure 4. Differential scanning calorimetry thermogram of heat reaction of plastic compound.

The bonding performance of cross three-layered LWPCs is listed and compared in Table 1. The failure modes are shown in Table 1 and Fig 5.

An optimum bonding level is necessary to achieve good strength, and the degree of adhesion can influence the mechanical properties of WPCs (Nourbakhsh and Ashori 2008). PE ingredient in plastic compound melted at 140°C, whereas PP ingredient remained rigid in plastic compound (see Fig 4). The bonding strength of the specimens with a pressing temperature of 140°C and the absence of MAH pretreatment was not obtained because the delamination between wood veneer and thermoplastic sheet occurred (see Table 1 and Fig 5) after they were tested with the "boiled-dried-boiled" method according to China Standard GB/T 17657 (2013). There was a better flow in the plastic compound because PP ingredient was softened at 160°C (see Fig 4). The bonding strength was higher than that of the LWPCs at 140°C. The bonding strength of the specimens with a pressing temperature of 140°C and the absence of MAH pretreatment was 0.69 MPa at the wood-to-plastic ratio of 3:3 and 3:2. The bonding strength achieved 1.09 MPa at a wood-to-plastic ratio of 3:1 (see Table 1). The

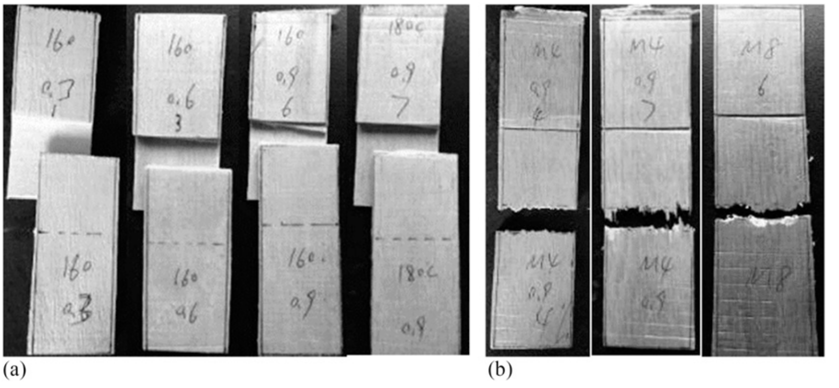
Table 1. Bonding performance of laminated wood plastic composites with different processing parameters.

Temperature (°C)	Wood-to-plastic ratio	Maleic anhydride concentration (%)	Bonding performance		
			Bonding strength (MPa)	Wood failure percentage (%)	Failure mode
160	3:1	0	1.09	0	Delamination
160	3:2	0	0.69	0	Delamination
160	3:3	0	0.69	0	Delamination
140	3:3	0	—[a]	0	Delamination
180	3:3	0	0.95	0	Delamination
160	3:3	4	0.80	100	Wood tension failure
160	3:3	8	0.70	100	Wood tension failure
180	3:3	4	1.12	100	Wood tension failure

[a] Indicated that the specimen was delaminated.

difference between the bonding strength of specimens with various wood-to-plastic ratios may be attributed to the reduction of wood material because the cracks occurred in the specimens with a higher wood-to-plastic ratio. As the temperature increased to 180°C, melting plastic can flow easily and enter wood cell cavity, and more physical contacts occurred. The bonding strength of the specimens with a pressing temperature of 180°C and the absence of MAH pretreatment was 0.95 MPa at a wood-to-plastic ratio of 3:3 (see Table 1). The interfacial adhesion between wood veneers and plastic sheets in the absence of MAH pretreatment was poor according to the incompatibility between hydrophilic wood and hydrophobic plastic, which has been proved by many peer researchers (Maldas and Kokta 1989, 1993; Raj et al 1989).

Further improvement on bonding strength of LWPC manufactured at 180°C can be obtained after the wood veneers were pretreated with MAH. The bonding strength of LWPC with a wood-to-plastic ratio of 3:3 and 4% MAH pretreatment was 17.89% higher than that without the MAH pretreatment. It was reported that carbonyl stretch and anhydride exhibited a characteristic doublet because of carbonyl stretch of coupling agents (MAH) by fourier transform infrared spectroscopy FTIR analysis (Nourbakhsh and Ashori 2008) because the copolymer was bonded to the fibers by ester linkages and hydrogen bonds as MAH was used (An and Ma 2017).



(a) (b)

Figure 5. Failure modes of boiled three-layered laminated wood plastic composites: interfacial delamination (a) and wood tensile failure (b).

For failure mode, there was a significantly difference among the LWPCs with the absence or presence of MAH pretreatment (see Table 1 and Fig 5). Owing to the poor interfacial compatibility between hydrophilic wood and hydrophobic plastic, a strong connection between the wood and plastic was not built without pretreatment with a coupling agent. Therefore, interfacial failure mode of cross three-layered LWPC specimens was delamination if the temperature was less than the melting points of the plastic compound, and MAH was not used (see Fig 5(a)). As the temperature was higher than the melting point of the thermoplastic compound and MAH was added, a strong interfacial connection between wood and plastic occurred, and the failure mode was wood tensile failure (see Fig 5(b)). Bonding strength of LWPC specimens with an excessive amount of MAH decreased, and the reduction may be explained by its low molecular mass inducing a plasticization effect (Krzysik and Youngquist 1991). However, the bonding performance between wood and plastic was still not strong if only physical connection was built because the wood failure percentage and failure mode both were not poor (see Table 1). A bonding in combination with chemical and physical connection was necessary for LWPC (see Table 1).

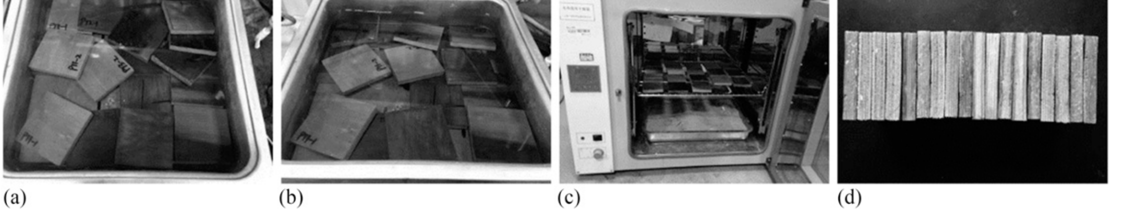
Based on the above test results, the parallel multilayered LWPCs with pretreatment by 4% content MAH were manufactured with a hot-pressing temperature of 180°C. The densities of parallel multilayered LWPCs were set 0.6 g/cm^3, 0.8 g/cm^3, and 1.0 g/cm^3, respectively. Wood-to-plastic ratios were set 3:1, 3:2, and 3:3, respectively.

There were strong interfacial adhesion in combination physical connection and chemical bonding between wood veneer and plastic compound. The ratio of delamination was 0%. The results to be drawn from boiling water soak delamination test (see Fig 6) were in favorable agreement with the findings (see Fig 5).

Mechanical Properties

The MOR and MOE in bending are very important properties measuring the material's biggest bending capacity and resistance to deflection. The parallel-to-grain tensile strength represents the axial bearing capacity of the material. They are all the premise of the application and design of structural building materials. The influences of density and wood-to-plastic ratio on MOR, MOE, and tensile strength are listed in Table 2 and Fig 7.

According to the literatures (Li et al 2013; Wei et al 2013a; Arab and Islam 2015; Yang et al 2015; Srivabut et al 2018), the MOR, MOE, and tensile strength of conventional WPCs were 13.1-46.3 MPa, 1781-3170 MPa, and 15.3-29.4 MPa, respectively. In this study, the MOR and tensile strength of parallel multilayered LWPCs were 37.52-51.12 MPa and 20.49-31.47 MPa, respectively, and had shown generally same mechanical properties as those of the conventional WPCs. A significant improvement of MOE was obviously observed in Fig 7(a) and Table 2. The MOE of parallel multilayered LWPC ranged from



(a) (b) (c) (d)

Figure 6. The multilayered parallel laminated wood plastic composites for bonding performance testing with boiling water soak delamination test: immersed in boiling water for 4 h (a), immersed in normal temperature water for 1 h (b), dried thermostatic drier for 24 h at 70°C (c), and the specimens after delamination tested.

Table 2. Mechanical properties of laminated wood plastic composites using various configuration.

Composites code	Wood-to-plastic ratio	Density (g/cm^3)	Bending strength (MPa)	Tensile strength (MPa)	MOE (MPa)
W1D6	3:1	0.6	40.36	31.47	11,490
W2D6	3:2	0.6	45.09	25.03	10,201
W3D6	3:3	0.6	46.51	20.49	10,428
W1D8	3:1	0.8	46.25	29.83	9846
W2D8	3:2	0.8	47.61	27.96	9782
W3D8	3:3	0.8	48.89	25.55	8880
W1D10	3:1	1.0	51.12	30.57	11,231
W2D10	3:2	1.0	39.19	28.71	11,102
W3D10	3:3	1.0	37.52	26.21	9347

8880 MPa to 11,490 MPa and were 2.8-3.6 times that of conventional WPCs.

A considerable effect of density and wood-to-plastic ratio on mechanical properties was found. As the density was 0.6 g/cm^3 or 0.8 g/cm^3, MOR increased with the increase in wood-to-plastic ratio. As the density was 1.0 g/cm^3, the MOR peaked at 3:1 wood-to-plastic ratio, and then all decreased with the increase in wood-to-plastic ratio. For the parallel multilayered LWPCs with a density of 0.6 g/cm^3, MOR at a wood-to-plastic ratio of 3:3 was 46.51 MPa and was 15.24% higher than that at a wood-to-plastic ratio of 3:1. When the density of parallel multilayered LWPC was 0.8 g/cm^3, the MOR had a light increase by 5.71% as the wood-to-plastic ratio increased from 3:1 to 3:3. The MOR of parallel multilayered LWPCs with a density of 1.0 g/cm^3 was 51.12 MPa at a wood-to-plastic ratio of 3:1, and then decreased to 37.52 MPa at a wood-to-plastic ratio of 3:3.

The MOE and tensile strength of LWPCs both decreased with the increase in wood-to-plastic ratio, when the density remained constant. The negative influence of the high plastic contents on MOE and tensile strength of the specimens can be attributed to the defective glue line or the reduction of mechanical properties of wood veneer. The MOEs of the specimens with a wood-to-plastic ratio of 3:1 were 11,490 MPa, 9846 MPa, and 11,231 MPa when the density of the specimens was 0.6 g/cm^3, 0.8 g/cm^3, and 1.0 g/cm^3, respectively. The MOEs of LWPCs with a wood-to-plastic ratio of 3:3 were 10.18%, 10.88%, and 20.16% less than that at a wood-to-plastic ratio of 3:1 when the density of the specimens was 0.6 g/cm^3, 0.8 g/cm^3 and 1.0 g/cm^3, respectively. The effects of wood-to-plastic ratio and density on the

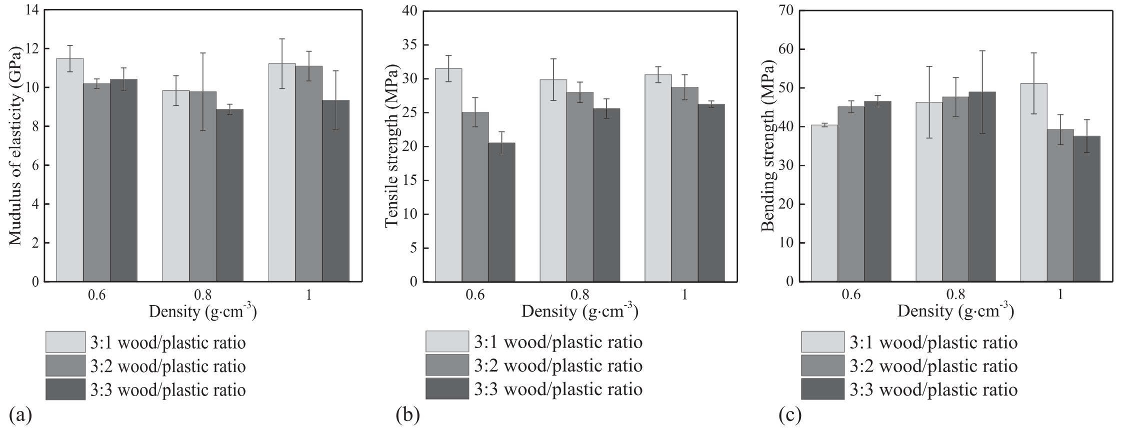


Figure 7. MOE (a), bending strength (b), and tensile strength (c) of parallel laminated wood plastic composites with various wood-to-plastic ratio and density.

tensile strength was similar to that on MOE, and the specimens manufactured with a wood-to-plastic ratio of 3:1 and a density of 0.6 g/cm^3 had a high tensile strength value of 31.47 MPa and was higher than any other LWPCs.

SEM Observation

To reveal the interfacial relationship between wood and plastic, original image and microscopy at various magnifications of LWPCs are presented in Figs 8 and 9.

Obvious layer structure was observed as the density and wood-to-plastic ratio of LWPC were low (Fig 8(a)). Figure 8(a) exhibited clear bondlines between wood and plastic in LWPC. The microscopic images at a magnification of 50 indicated large amounts of thermoplastics in the vessels (Fig 8(b)). A closer observation with SEM at a magnification of 200 revealed the prevailing deposition of plastics in small cavities, ie poplar fiber (Fig 8(c)), suggesting a physical interaction between wood and plastic was built. Because there were so much physical anchoring and glue nails of plastic in wood cavities and the chemical adhesion by coupling agent, desirable bonding strength was obtained. So, effective stress can be transferred from one wood laminate to another by the strong interface, and then mechanical properties of WPCs can be greatly improved by lamination configuration described in the present study, especially for MOE, and LWPCs can be used as a load-bearing material in construction.

It is important to note that the impact of the integrity of wood cell wall and the interfacial connection on mechanical properties of WPCs was significant. The bondlines between wood and plastic in LWPC was dim as the density and wood-to-plastic ratio of LWPC were high because the wood layer showed discontinuity and their thickness was not uniform (Fig 9(a)). SEM images in Figs 8(c) and 9(c) reveal the reasons for difference of mechanical properties of LWPCs with different densities and wood-to-plastic ratios at the micro level. Crack and wood cell collapse observations (Fig 9(c)) indicate the wood yielded across the grain owing to the higher density. The thermoplastic plastics in LWPCs expanded after were thermally liquefied, and then contracted after hot pressing. It was obvious that the difference of volumetric change between wood and plastics was significantly great. The greater the wood-to-plastic ratio was, the larger the difference in volumetric change between wood and plastics was. As a consequence, an obvious delamination between wood and plastic in the wood cell cavity occurred, as shown in Fig 9(c).

CONCLUSIONS

This study focused on the influence of the pretreatment and processing parameters on the bonding performance of LWPCs. The most important objective of this study was to provide a structural wood-based material from fast-growing wood.

Using parallel lamination, MOR and bending strength of WPCs were both generally same as those of the conventional WPCs with wood flour or fiber. The MOE of LWPC was improved significantly and was at least 2.8 times that of

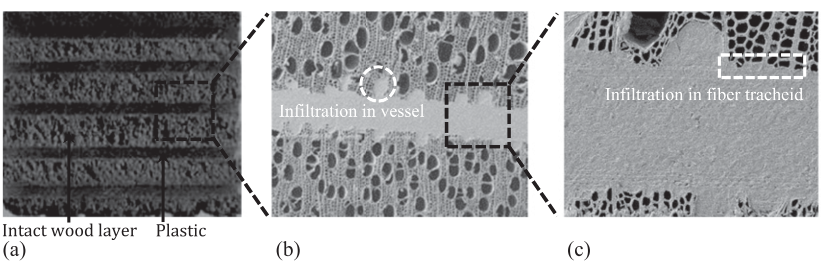


Figure 8. Original image (a), 50× (b), and (c) 200× scanning electron microscopy images of the interface between wood and plastic with a density of 0.8 g/cm^3 and a wood-to-plastic ratio of 3:1.

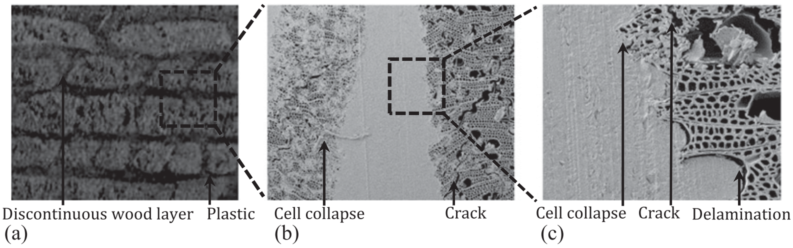


Figure 9. Original image (a), 50× (b), and (c) 200× scanning electron microscopy images of the interface between wood and plastic with a density of 1.0 g/cm^3 and a wood-to-plastic ratio of 3:3.

the conventional WPCs. SEM showed that the penetration of thermoplastic compound into the wood cell wall and strong interfacial connection were obtained. The impacts of density and wood-to-plastic ratio on mechanical properties of LWPCs were significant in accordance with the mechanical properties testing and SEM observation. The LWPC with a density of 0.6 g/cm^3 and wood-to-plastic ratio of 3:1 has the highest MOE value of 11,490 MPa, and the bending strength and tensile strength were 40.36 MPa and 31.47 MPa, respectively. The invention of the structural wood-based composites can increase the added value of fast-growing wood species and improve the income of the peasants.

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